Progress M-27M Mission Updates

Launch Vehicle Overview, (http://www.spaceflight101.com/soyuz-2-1a.html) Spacecraft Information, (http://www.spaceflight101.com/progress-spacecraft-information.html) Flight Profile (/progress-m-27m-flight-profile.html), Cargo Manifest (/progress-m-27m-cargo-manifest.html), Mission Chronology (/progress-m-27m-chronology.html)

Progress M-27M Re-Entry: Background & Updates (/progress-m-27m-re-entry.html)

Flawed Separation System blamed for Loss of Progress M-27M Craft

June 1, 2015

The Russian Federal Space Agency reported the findings of the investigation into the failure of the Progress M-27M mission. According to the investigative State Commission, significant damage was caused to the Progress cargo craft at the time of separation from its Soyuz 2-1A launch vehicle due to a design flaw in the separation system and related frequency-dynamic characteristics.

(/uploads/6/4/0/6/6406961/5675342_orig.jpg)
Photo: RSC Energia

Progress M-27M was set for a fast trip to the International Space Station on April 28, lifting off from the Baikonur Cosmodrome aboard a Soyuz 2-1A rocket. After nearly nine minutes of powered flight, the spacecraft was separated into orbit, but it was quickly found that communications with the craft were deteriorating. Commanding of Progress was completely lost and the vehicle appeared to be tumbling in an orbit 40 Kilometers higher than planned. Over 50 pieces of debris were scattered into orbit, confirming that a significant event had taken place at or around separation from the Soyuz rocket.

A detailed analysis of telemetry revealed that a number of events transpired in the last seconds of the operation of the third stage of the Soyuz – starting with a delayed engine cutoff command on the third stage that came around 1.35 seconds after the expected time. Next, telemetry from several sources on the launch vehicle and spacecraft became intermittent, but data was sufficient to detect accelerometer measurements on the third stage that indicated a premature separation of the Progress spacecraft. Also, a sudden depressurization of the oxidizer and fuel tank occurred within a fraction of a second after separation – indicating that stresses occurring at separation led to a loss of structural integrity on the third stage. (Detailed timeline of events in our previous mission update below.)

Given the gaps in data from both Soyuz and Progress as well as the complexity of the failure mechanism that seemed to have transpired, teams had to push the release of their conclusion by several weeks.

Initially, the cause of the failure was determined to be the depressurization of tanks on the third stage leading to an improper separation of the Progress. Now, in their final findings, the State Commission reversed that statement and identified the botched separation of the spacecraft to be the cause of the tank depressurization.

(/uploads/6/4/0/6/6406961/9916102_orig.jpg)
Photo: RSC Energia

Progress M-25M Payload Adapter

In the Roscosmos statement issued on Monday, the agency announced that the likely culprit in the Progress M-27M failure lies within a design flaw in the spacecraft separation system and associated frequency-dynamic characteristics. According to the State Commission, these properties were not fully studied as part of the design work that went into the accommodation of Soyuz and Progress spacecraft atop the Soyuz 2-1A rocket.

No exact details were given by Roscosmos with respect to the design peculiarity associated with the frequency oscillations observed within the separation mechanism. In October, the first Progress craft to launch aboard Soyuz 2-1A (/progress-m-25m-mission-updates.html) enjoyed a seemingly flawless ride into orbit, with no problems at separation – raising the question on what was different between the successful Progress M-25M launch and the failed M-27M mission.

No direct explanation was provided by Roscosmos for the deviation of the 3rd stage shutdown time and the higher than planned apogee of the insertion orbit.

Despite the costly failure of Progress M-27M, the concept of introduction of the Soyuz 2-1A chosen by Roscosmos is paying off now. Starting to inaugurate the modern 2-1A version of Soyuz in Progress missions several years before committing crewed Soyuz missions to launches aboard the vehicle provided teams with an opportunity to test out the entire launch sequence and identify any deficiencies without human life at risk. Additionally, alternating between Soyuz U and 2-1A for several Progress missions provides an increased period of time between subsequent 2-1A launches to allow engineers to work on the optimization of systems and sequences.

(/uploads/6/4/0/6/6406961/5611960_orig.jpg)
Photo: RSC Energia

Impacts to the older Soyuz U and FG rockets will be assessed in a study of commonality between the various separation systems before Roscosmos will announce a firmed up schedule for upcoming Progress and Soyuz missions to the International Space Station. This announcement is expected on June 9. Currently, the next Progress mission to ISS is targeting a launch in early July with Soyuz TMA-17M following three weeks later to bring the Expedition 44/45 crew to the orbiting laboratory.

Roscosmos said that there would be no limitations to the operation of Soyuz 2-1A with other spacecraft, essentially clearing all non-Progress or Soyuz launches atop the Soyuz 2. The next launch of Soyuz 2-1A, now likely to take place in the next four weeks, is the Kobalt-M #10 (/kobalt-m---soyuz-2-1a-launch-updates-2015.html)mission launching from Plesetsk – the very last film-return reconnaissance satellite to be launched. The Persona #3 electro-optical reconnaissance satellite is set for liftoff atop a Soyuz 2-1B within a month of Kobalt.

Many open Questions remain in Progress M-27M Failure Investigation

May 28, 2015

The investigation into the dramatic failure of the Progress M-27M mission has proven to be one of the most difficult inquiries the Russian Space Agency has ever been faced with. Progress M-27M encountered a fatal incident at or around the time of separation from the Soyuz 2-1A launch vehicle that lofted the craft into orbit back on April 28. A loss of telemetry data from both craft has made it difficult to piece together what happened to the Progress or the third stage of the Soyuz and so far, no firm conclusion was reached by the investigation committee since there are still several theories on potential causes of the mission failure.

Progress M-27M made its way into orbit in the morning of April 28, launching from the Baikonur Cosmodrome atop a Soyuz 2-1A rocket, becoming the second Progress craft to use the modern 2-1A version of the Soyuz. Embarking on what was planned to be a six-hour rendezvous with the International Space Station, Progress enjoyed a nominal ascent until the point of third stage shutdown and spacecraft separation.

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Photo: Tsenki/Roscosmos

Immediately after separation, teams on the ground lost communications with the Progress craft that was later tracked in an orbit with an apogee 40 Kilometers higher than planned while the third stage entered a lower orbit, with a 20km deviation against the planned apogee. The Progress craft was declared lost less than a day after launch when the vehicle was seen spinning in an uncontrolled fashion without any commanding possible from the ground. Also, a number of debris were detected up in orbit as the result of an energetic event taking place at spacecraft separation.

In the first days after the incident, teams attempted to piece together the telemetry that was available to them, starting with the spacecraft that had shown at least sporadic bits of data over the course of its initial orbits. Data from the spacecraft showed that one of the two propellant manifolds of the Progress had been depressurized – likely as a result of debris strikes occurring at separation. The venting of pressurized gas and/or propellant provided an explanation for the uncontrolled tumbling of the spacecraft. Data from Progress also showed that the Flight Computer of the vehicle had failed.

Studying telemetry from the launch vehicle, teams quickly found inconsistencies from the normal flight plan in the last three seconds of the operation of the third stage. It was initially found that the GK-3 command – the RD-0110 engine shutdown command – came 1.35 seconds after the planned time (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1370005/#message1370005) of T+524.97 seconds. However, the engine of the third stage showed a perfectly normal shutdown sequence with a good spin-down of the turbopump, dropping pressures in the chambers and gas generator, and the normal closure of oxidizer and fuel valves.

(/uploads/6/4/0/6/6406961/3326279_orig.jpg)
Photo: RSC Energia

Soyuz Block I Stage

Starting 0.2 seconds after the onset of engine shutdown (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1373210/#message1373210), a number of sensors on the third stage began showing non-sensical values that indicated that their connections to the avionics units were cut. Data from the third stage was lost at T+526 seconds with the exception of some fragments of telemetry that were downlinked to ground stations. This data showed that some of the functions of the third stage remained intact until the scheduled shutdown of the vehicle's telemetry system 24 seconds after spacecraft separation. (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1373642/#message1373642)

On May 12, Roscosmos issued a press release in which the agency confirmed the deviation of the spacecraft orbit that was 40km above nominal and the third stage of Soyuz that was 20km lower than expected. It was also confirmed that the spacecraft was separated at T+526.716 seconds, about three seconds prior to the planned time. The State Commission had reached a preliminary conclusion that an off-nominal separation between the rocket and the spacecraft took place leading to the subsequent depressurization of the oxidizer tank of the third stage followed by the fuel tank.

The disintegration of the third stage can explain the damage suffered by the Progress and the amount of debris seen in orbit. Roscosmos said that the findings were still preliminary and a number of simulations and hardware experiments were still ongoing.

A source with access to Soyuz telemetry provided the following data on the Novosti Kosmonavtiki forum: (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1379417/#message1379417)

- T+526.32 – Orbit Confirmation Command
- T+526.44 – GK3 – Engine Shutdown Command
- T+526.56 – Onset of RD-0110 Shutdown
- T+526.56-526.58 – Loss of Spacecraft Telemetry
- T+526.56-526.62 – Loss of Launch Vehicle Telemetry
- T+526.62-526.65 – Axial Acceleration measured by sensors, in line with S/C Separation Pyro Firing
- T+526.66 – Acceleration to the aft direction of Rocket Body, likely the result of S/C Separation
- T+526.68 – Separation Confirmation through Sensors
- T+526.69 – Sudden Loss of Pressure in Oxidizer Tank
- T+526.75 – Sudden Loss of Pressure in Fuel Tank
- T+550 – Deactivation of LV Telemetry System

Russian sources reported that one possible explanation for the failure of the third stage oxidizer tank was a fault introduced during manufacture (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1379301/#message1379301)w the forward bulkhead of the tank was welded to the cylindrical section of the tank. In this particular case, two welds were made between the central cylinder and the bulkhead where normally a single weld is sufficient. The disintegration of the LOX tank could have explained the presence of an axial force shortly after engine cutoff and the energy released when the forward bulkhead became detached would have been capable of propelling the 3rd stage and spacecraft into vastly different orbits.

But the theory of LOX Tank Failure was doubted by a number of engineers and TsSKB Progress, the manufacturer of the Soyuz rocket,

(/uploads/6/4/0/6/6406961/7803839_orig.jpg)
Photo: RSC Energia

Forward End of Block I Stage

presented cases where up to five welds were made on the LOX tank without impact to the quality of the seam. Engineers from TsNIIMash conducted testing on an oxidizer tank (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1380094/#message1380094)tl also underwent dual welding of the upper bulkhead and pressurized it to 10.2 bar, well above the normal pressure of 4.6 bar seen in flight, supporting the theory that the oxidizer tank was not to blame.

It turned out that the oxidizer tank was identified primarily because it was the only component that was believed to be able to supply the 12m/s of delta-v needed to send Progress into the higher orbit as opposed to the fuel tank that only operates at a pressure of 2.2 bar that would not deliver sufficient energy to account for the observed orbits.

TsNIIMash also conducted testing related to the batteries of the Soyuz Block I (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1380086/#message1380086) upper stage. According to information posted on Novosti Kosmonavtiki, testing was performed on the Nickel-Cadmium batteries used on Block I to assess the possibility of a battery explosion in case of a short circuit.

Another theory (http://novosti-kosmonavtiki.ru/forum/forum10/topic14472/?PAGEN_1=127)calls for a mismatch between sequencers aboard the launch vehicle and the spacecraft that normally have to operate in synchronization to jointly perform the separation sequence. Residing on the payload adapter and the Progress spacecraft are a total of three pyrotechnic separation systems that use loaded springs to push the vehicles apart. The part of the system residing within the payload adapter are commanded by the Launch Vehicle while the cutting of interfaces on the Progress side is accomplished by command from the spacecraft. These two systems normally operate at the same time, but without interconnection between them with two separate sequencers commanding the separation events.

(/uploads/6/4/0/6/6406961/7113352_orig.jpg)
Photo: RSC Energia

Progress M-M Payload Adapter & Separation System

Available telemetry from the launch vehicle indicates that it never sent the separation command that was timed for T+528.27 seconds. Instead, the acceleration at T+526.66 seconds is indicative of the spacecraft completing its separation nearly three seconds ahead of time and just 0.22 seconds after the engine cutoff command was issued aboard the launch vehicle. Normally, the interval between the GK3 cutoff command and the S/C separation command would be 3.3 +/-0.3 seconds with another 0.13 seconds of latency between the command and the firing of pyros. Given this timeline, it would seem that the Progress spacecraft jumped the gun at separation, disconnecting itself from the launch vehicle when the engine shutdown sequence was still underway.

However, this scenario still leaves a number of open questions regarding the deviation in the GK3 engine shutdown command that came over a second after the nominal time. It still remains to be answered why the spacecraft separation was triggered about 1.5 seconds ahead of the planned time of T+528.27 – just fractions of a second after engine shutdown was started. The events occurring after the faulty separation also remain to be explained as a depressurization of both propellant tanks and the release of over 50 pieces of debris can only occur as part of an energetic event – either a rupture in the LOX tank that was hypothesized earlier, another type of destructive event intrinsic to the launcher or spacecraft, or damage caused by re-contact between launcher and spacecraft.

(/uploads/6/4/0/6/6406961/1675254_orig.jpg)
Photo: RSC Energia

Given the degree of difficulty in pin-pointing the exact causes of the loss of Progress M-27M, Roscosmos pushed the deadline for the conclusion of the investigation multiple times, first from mid-May and then from May 22 to May 26 which also passed without any new information on the status of

the investigation.

Soyuz launches continue to be on hold to await the findings of the commission - if the root cause can not be determined within the month of June, Soyuz could run into serious scheduling issues. Two launches from the Plesetsk Cosmodrome have already been postponed – the launch of the final Kobalt-M (/kobalt-m---soyuz-2-1a-launch-updates-2015.html) satellite atop Soyuz 2-1A and the launch of the Persona #3 (/persona.html) reconnaissance satellite on the 2-1B version. The next Progress mission to ISS would use the older Soyuz U rocket and has been preliminarily set for July 3, but this launch will only be able to go ahead if this issue can be traced back specifically to hardware used by the Soyuz 2-1A and not the Soyuz U. If the Progress spacecraft was at fault, the issue of commonality between the crewed Soyuz and the Progress vehicle would arise with the next Soyuz launch currently set for July 24.

Photo: NASA

Grounding of Soyuz Rocket prompts Space Station Schedule Revision

May 12, 2015

The International Space Station program has worked out schedule changes in the wake of the recent Soyuz launch vehicle failure, leaving the Progress M-27M cargo resupply spacecraft on the fast lane to re-entry instead of the expressway to the orbiting outpost. The Soyuz rocket is likely looking at an extended grounding while teams work out how to recover from the recent failure, requiring a number of changes to planned ISS operations.

>>>ISS Update (/grounding-of-soyuz-rocket-prompts-space-station-schedule-revision.html)

Progress M-27M Failure Investigation focuses on Soyuz Rocket

May 5, 2015

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Photo: Tsenki/Roscosmos

Progress M-27M, on the fast route to re-entry (/progress-m-27m-re-entry.html) instead of the express lane to the Space Station, was likely set on its course toward an untimely demise by a failure within the upper stage of the Soyuz 2-1A rocket that launched it into orbit. Still in the initial stages of the investigation, teams determined with high certainty that there was no fault with Progress itself, but data points to potential problems late in the operation of the rocket's third stage - possibly a spacecraft separation issue or an explosion on the booster.

Launched back on April 28 atop a Soyuz rocket, Progress initially had a smooth ride into orbit until trouble emerged very late in the operation of the third stage, also known as Block I. At first, Mission Controllers were only alerted to an apparent loss of communications from the Progress spacecraft that could not properly complete its initial orbital operations – successfully deploying its solar arrays, but failing to extend all of its KURS navigation antennas or keeping one of its propellant manifolds at pressure.

Tracking of the spacecraft revealed that Progress ended up in a higher than planned orbit with an apogee around 35km higher than expected, representing an overperformance of 10 to 12 meters per second.

Progress M-27M was found to be tumbling in an uncontrolled fashion later in the day and communications with the spacecraft were difficult, allowing the reception of some data, but not to dampen the body rates on the spacecraft that was declared lost around 24 hours after its launch. Around the same time, the Joint Space Operations Center reported tracking over 40 pieces of debris in an orbital trajectory close to the Progress spacecraft and Block I rocket stage.

Later in the day, reports emerged indicating that problems occurred either late in the burn of the third stage or during the separation sequence of the spacecraft. Sources close to the Progress mission indicated that they found that Progress did suffer damage through a problem external to the spacecraft.

Analysis of telemetry data showed that the command to shut down the RD-0110 engine of the Block I stage came 1.35 seconds after the expected time of 524.97 seconds. (http://novosti-kosmonavtiki.ru/forum/messages/forum10/topic14472/message1370786)
Data from the engine shows pressures in the oxidizer system dropping as expected, but data from both communications channels was lost within close succession within a fraction of a second after the start of the engine cutoff. Telemetry from the Progress was lost moments before that, indicating some type of energetic event to have taken place involving the third stage as well as the spacecraft, taking out a subset of systems on both vehicles.

It was expected that separation of the Progress takes place 3.3 seconds (+/-0.3sec) after the GK-3 shutdown command was sent, but the separation of the spacecraft could not be followed in telemetry data, that had already been lost. The Progress payload adapter facilitates three spring-loaded pushers that are actuated to separate the spacecraft along a series of guide pins, providing it with sufficient separation velocity to

clear the third stage of the Soyuz.

Block I was programmed to open up a reaction nozzle on its side around 0.7 to 1.3 seconds after spacecraft separation, venting out pressurized oxygen from the LOX tank as an avoidance maneuver, sending the stage away from the Progress, but also causing a tumble due to the unsymmetrical distribution of thrust on the body of the rocket stage.

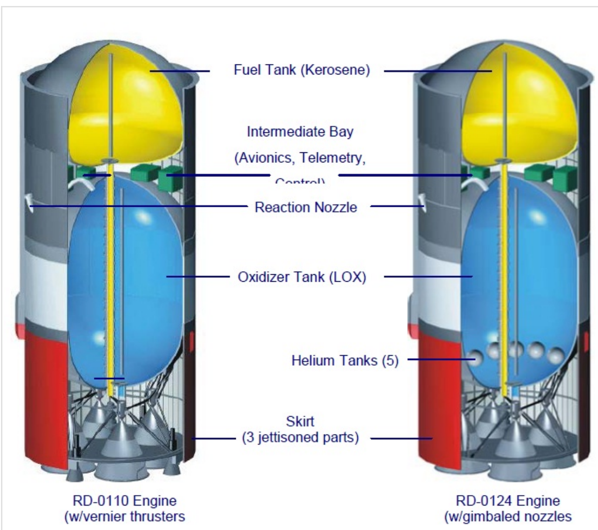
Evidence points to an explosion occurring on the Block-I stage, leading to the destruction of the communications equipment of the third stage and ejecting debris that punctured propellant lines or tanks on the Progress spacecraft, leading to the depressurization of one of two propellant manifolds on the spacecraft.

(/uploads/6/4/0/6/6406961/4814564_orig.jpg)
Photo: Roscosmos

Progress Payload Adapter & Separation Interface

The venting fuel and/or pressurant is suspected to be the culprit in the observed body rates on the Progress, but it is also possible that the explosion on the third stage sent the stack into a tumble before the spacecraft was separated.

The communications equipment of the Block I stage is located in the intertank compartment between the LOX and Kerosene tank, making it vulnerable in the event of a tank rupture or explosion. The simultaneous drop-out of communications from both channels can certainly be explained by an explosion of the third stage and so could the discrepancy in the initial insertion orbit as an exploding tank could easily send the Progress into a higher orbit.



(/uploads/6/4/0/6/6406961/9818459_orig.jpg)
Image: Arianespace

Soyuz 2 Third Stage Design

For the Progress, there was no option for recovery given its unusual situation with significant body rates and possible damage to a number of systems in the Instrumentation Module at the base of the spacecraft, leading to an apparent failure of the onboard computer of the cargo craft.

The cause of the energetic event on the third stage remains unknown, however, a number of theories have emerged. The manufacturer of the RD-0110 engine KBKhA reported just a few hours after launch that the engine operated to specification but the control system commanded it to overperform, indicating possible issues with the Flight Control System. If the engine was indeed operated beyond its nominal environment, the possibility of an improper shutdown due to propellant depletion leading to a violation of structural limits and subsequent tank rupture could explain the known facts.

One of the changes between Block I stages of the older Soyuz versions (U and FG) and the modern Soyuz 2 is a different design of the Kerosene tank that, instead of a spherical tank structure, is comprised of a flat bulkhead in the aft, a cylindrical segment and a spherical bulkhead in the forward tank portion. This tank design flew 45 times aboard Soyuz 2 rockets compared to over 1,500 flights by the heritage design – the RD-0110 engine itself can look back at over 1,200 missions and its predecessors also flew a large number of missions.

The Russian Space Agency continues its failure analysis that is now focusing on the third stage of the Soyuz to carefully piece together the sequence of events that led the launcher to damage the Progress so severely that it could no longer function in orbit. If a design flaw can be ruled out, commonality between this launch vehicle and others will be looked at to check for potential production-related issues either on the structure, engine or Flight Control System of the Soyuz 2-1A.

The next Soyuz 2-1A launch was planned on May 15 from the Plesetsk Cosmodrome carrying a Kobalt-M film-return reconnaissance satellite (/kobalt-m---soyuz-2-1a-launch-updates-2015.html) into orbit. Officials already stated that the launch would only be carried out when the preliminary report on the Progress M-27M failure – expected on May 13 – fully exonerates the third stage.

Reviews will also be performed to assess the risk to the Soyuz FG rocket, that uses the older Flight Control System and tank design, but an overall similar architecture of the Block I stage and the same RD-0110 engine.

Soyuz FG was expected to launch from Baikonur on May 26, carrying three International Space Station Crew members into orbit. No firm decisions on any schedule has been made, however, the current departure date for Soyuz TMA-15M and the ISS Expedition 42/43 crew remains set for May 14. If the landing is carried out as scheduled and

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Photo: RSC Energia

the Soyuz rocket is grounded based on the findings of the investigation, the Space Station may be staffed by a crew of three for an extended period of time.

In the meantime, Progress M-27M is well on its way towards re-entry, expected to occur around Friday. Updated predictions and information related to the orbital decay of the spacecraft is available here. (/progress-m-27m-re-entry.html)

Progress Spacecraft declared Lost, approaches Entry - Failure Analysis begins

>>>Mission Chronology (/progress-m-27m-chronology.html) >>>Soyuz Booster Re-Entry (/progress-m-27m---soyuz-third-stage-re-entry.html) April 29, 2015

The Russian Space Agency has officially declared the Progress M-27M spacecraft lost on Wednesday after repeated attempts to regain control of the vehicle were without fruition. Progress M-27M, loaded with 2,357 Kilograms of supplies for the International Space Station, lost a number of its onboard systems shortly after launch on Tuesday leading to an uncontrolled tumbling motion on the spacecraft, ultimately ending the mission due to the vehicle's inability to communicate with the ground and failures in several critical onboard systems.

There is no immediate danger to the six crew members living and working aboard ISS since the Station is in a relatively comfortable situation, stocked up on supplies and spare components to continue normal day-to-day operations. It will be more important to piece together exactly what happened to the troubled Progress to avoid future missions, including those of the crewed Soyuz spacecraft, to run into similar problems.


(/uploads/6/4/0/6/6406961/_8072189_orig.jpg)
File Image - Photo: Oleg Artemyev

The Progress itself remains in a passive state, orbiting the Earth just over 200 Kilometers in altitude and remaining in a spinning motion. Without any chance of controlling the spacecraft from the ground, Mission Control will only be able to watch the slow drop of the craft towards the dense layers of the atmosphere leading up to an uncontrolled re-entry. It is still too early to issue any firm re-entry predictions, but basic orbital propagation puts the re-entry of the 7,289-Kilogram spacecraft around May 10 (+/-3 Days).

The mission for the Progress started on Tuesday at 7:09:50 UTC when the craft blasted off atop a Soyuz 2-1A rocket launched from the Baikonur Cosmodrome in Kazakhstan. Performance of the booster was by the book, or so it appeared judging by the calls made from the Lunch Bunker where telemetry from the rocket was analyzed in real time. All events of the early ascent seemed normal and on time and Soyuz headed off into orbit powered by its third stage and the RD-0110 engine, a design that made over 1,500 flights over several decades.

Spacecraft separation was announced just under nine minutes into the flight and all eyes were on the telemetry screens to watch out for the data indicating Progress had deployed its solar arrays and KURS antennas and prepared its propulsion system for a high-speed chase of the Space Station with docking scheduled not six hours after liftoff – but no data showed up. Progress was found to be sending sporadic bits of telemetry and a 14-second video segment of the KURS navigation display was caught by a tracking station under the vehicle's orbital ground track.


(/uploads/6/4/0/6/6406961/_5938986_orig.jpg)

In a statement issued by Roscosmos on Wednesday, the agency announced that the mission headed for trouble in the late stages of the operation of the third stage. Telemetry from the Progress spacecraft and the Block I third stage of the Soyuz was lost 1.5 seconds before the planned separation of the Progress – meaning that the third stage shutdown at T+8:44.97 was seen on telemetry, but the feed cut out around T+8:46.8 and did not cover the subsequent separation event that was planned at T+8:48.27. The fact that data from both, the booster and spacecraft, was lost suggests that both were somehow involved in a catastrophic event that placed the mission on a path to failure.

After the initial trouble transpired in the minutes following spacecraft separation, Mission Control changed the profile of the mission from the rapid four-orbit rendezvous to a 34-orbit flight plan with docking expected on Thursday. These plans were put to rest later on Tuesday when it became clear that the problems of the Progress were much more serious than initially expected.

Photo: Roscosmos/Tsenki

Mission Controllers in Moscow attempted to make contact with the Progress on subsequent ground station passes, but only received bits of data. The reception of video on the other hand, coming through a different downlink path, was much better and alerted Mission Controllers to a series of failures on the Progress that was seen spinning wildly with Earth whizzing past in the field of view of the external camera. The KURS Data Display showed a series of warnings indicating that Progress had lost attitude control and that multiple angular rate sensors stopped functioning.

(/uploads/6/4/0/6/6406961/_8620455_orig.jpg)
Photo: RSC Energia

Progress M-27M during Processing

The bits of data received from the Progress also confirmed that the propellant manifolds had depressurized, putting the final nail in the coffin and destroying any hope of saving the mission. Progress has two independent strings of Propulsion Systems that are part of the Unified Propulsion System (KTDU main propulsion system and DPO attitude thrusters use propellants from the same tanks).

It is understood that only one of the strings suffered a loss of pressure while the other was still available for use if commanding a switchover would have been possible.

U.S. space surveillance assets picked up the Progress and the spent Block I stage in orbit, but also detected at least 44 debris pieces in the vicinity of the craft that must have originated either from the third stage of the Progress spacecraft at or around the time of separation. The debris were found dispersed in different orbits with perigee altitudes from 153 to 180 Kilometers at apogee heights up to 358 Kilometers. Most of the debris had very short orbital lives given their low mass and altitude.

The presence of debris and their spread in orbit is a strong indication of an energetic event – either a rupture of a pressurized system (propellant tank/line, pressurant tank/line, gas tank, pressure vessel) or a collision between the Block I stage and the Progress. It is also possible that the debris were ejected into higher or lower orbits from the spinning Progress spacecraft.

Progress spent the overnight hours tumbling passively in its orbit around Earth before Mission Control repeated attempts to make contact with the craft on Wednesday, starting at 1:50 UTC. No data was received from the Progress on any of the attempts and Roscosmos ultimately accepted defeat and gave up the mission as Progress had likely depleted its batteries due to its inability to track the sun with the two solar arrays.

With the mission officially declared a failure, a detailed investigation into the circumstances of the loss of the Progress spacecraft began. Naturally, the usual finger-pointing was started behind the scenes almost immediately, evident by several news reports of subcontractors claiming their systems played no part in the loss of the cargo mission.

Before the mission was declared a failure, numerous theories were published on possible causes, all zeroing in on a problem with the Block I stage of the Soyuz or a bad spacecraft separation as opposed to an intrinsic failure of the Progress itself. The premature drop in telemetry seems to support these theories.

(/uploads/6/4/0/6/6406961/_1800765_orig.jpg)
Photo: RSC Energia

RD-0110 third stage engine during LV Assembly

A report issued by Tass cited KBKhA, the manufacturer of the RD-0110 engine, indicating that the engine operated normally, but was requested by the Flight Control System to overperform which may explain the +30-Kilometer overshoot on the apogee of the initial insertion orbit that was targeted at 238 Kilometers but ended up being a closer to 270 Kilometers.

However, only an overperformance could not be lethal to the Progress that could have adjusted its trajectory to still make it to ISS. Damage to the propulsion system and possibly the communication antennas of the craft could be explained by a re-contact between the third stage and the Progress – potentially due to a delayed or improper shutdown of the engine leading to residual thrust being present at separation causing the third stage to ram into the Instrumentation Module of the Progress where the propellant tanks and a number of communication antennas are located. A contact between the booster and spacecraft can also be an explanation for the tumbling motion seen on the Progress, but that may as well have been caused by a leak in a pressurized system.

Detailed analysis of data on the performance of the third stage will be performed to identify if and what went wrong in the seconds leading up to spacecraft separation. The bits of telemetry gathered from the Progress will also be scrutinized to piece together the most probable failure scenario that unfolded on Tuesday.

If the Block I stage of the Soyuz is at fault, future Soyuz missions may be facing delays including the launch of Soyuz TMA-17M that is expected to carry Oleg Kononenko, Kimiya Yui and Kjell Lindgren to ISS on May 26. Roscosmos and NASA will work together to look at the possibility of

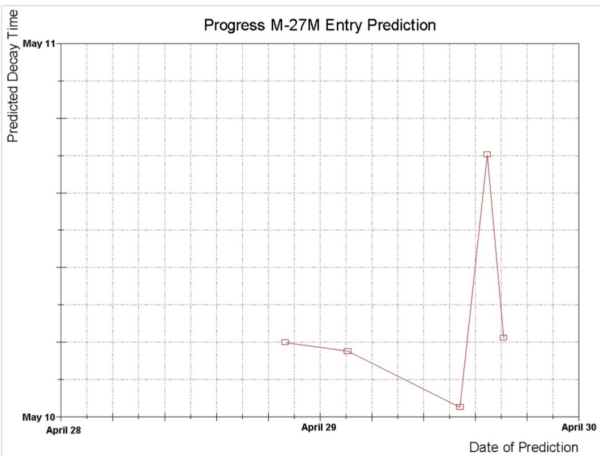
extending the stay of Soyuz TMA-15M at ISS in case a delay of the next Soyuz is needed.

(/uploads/6/4/0/6/6406961/_593138_orig.jpg)
Photo: Roscosmos

Progress & Payload Adapter with separation systems

There is one more scheduled Soyuz launch planned before the ISS flight, a Soyuz 2-1A launching from Plesetsk topped by a semi-classified Kobalt-M film-return reconnaissance satellite. (/kobalt-m---soyuz-2-1a-launch-updates-2015.html)
In case the fault lies solely within the systems of the Progress, teams would have to study the commonality between the unpiloted Progress and the crewed Soyuz craft that share a lot of systems from flight controls, over propulsion to navigation systems. A crew aboard the craft could intervene in case of problems with systems but it is doubtful that a Soyuz could be recovered from a failure within both of its propulsion system strings. Therefore a thorough analysis of Tuesday's troubled mission will be needed to rule out any possibility of a similar problem on a future flight.

Roscosmos said a preliminary report is expected by May 13. The next Progress spacecraft is set for launch in August, but may be brought forward by several weeks depending on the cargo situation aboard ISS and the results of the investigation.



(/uploads/6/4/0/6/6406961/_4441516_orig.jpg)
Image: Spaceflight101

For Progress M-27M, an untargeted, uncontrolled re-entry seems inevitable. Roscosmos will continue listening for signals from the spacecraft in the hopes of commanding a controlled deorbit, but given the state of the spacecraft the option of a safe end of the mission seems unlikely. The Russian Space Agency issued their initial re-entry estimate showing a period of May 5-7. Using orbital propagation tools that take into account atmospheric conditions, re-entry predictions of May 10 +/-3 Days can be obtained. As Progress slowly gets closer to the atmosphere, predictions will be refined so that on the day of re-entry, the position of orbital decay can be narrowed down to one orbit.

Re-entering the atmosphere, Progress will burn up and disintegrate to a large extent, but a number of pieces are known to survive re-entry and make it to the ground, including the Progress docking mechanism that is quite heavy, components of the main engine, and small spherical pressurant tanks. One large unknown is the propellant aboard the spacecraft that is stored in large tanks – if the toxic Unsymmetrical Dimethylhydrazine fuel and Nitrogen Tetroxide oxidizer freeze inside the tanks, some of the propellants may reach the ground.

A dedicated page covering the run-up to the re-entry of Progress M-27M will be set up this weekend. The Block I stage of the Soyuz has already re-entered, see the data here. (/progress-m-27m---soyuz-third-stage-re-entry.html)

Soyuz Third Stage Re-Enters Atmosphere

The Block I Upper Stage of the Soyuz 2-1A rocket that delivered the troubled Progress M-27M spacecraft to orbit re-entered the atmosphere early on Wednesday after a gradual decay of its low insertion orbit.

>>>Re-Entry Data Page (/progress-m-27m---soyuz-third-stage-re-entry.html)

Out-of-Control Progress Ship feared Lost in Space, Recovery Efforts continue

Repeated Contact Attempts yield no Response from tumbling Progress, Debris detected around Spacecraft

April 29, 2015


(/uploads/6/4/0/6/6406961/2585453_orig.jpg)
Photo: Oleg Artemyev (File)

The troubled Progress M-27M cargo spacecraft has more time than initially thought after orbital tracking revealed the craft to be in an orbit that has a longevity of several days instead of a few hours, providing additional time for the continued efforts to save the mission that currently stands close to failure. Mission Controllers in Moscow have resumed attempts in the early hours (UTC) on Wednesday to bring the craft back under control, but new information of debris found orbiting close to the spacecraft points to serious damage on the Progress spacecraft. Although the mission has not yet been declared a failure, the loss of the spacecraft seems inevitable.

After the fear of an early orbital decay could be alleviated, Mission Controllers are now facing problems associated with conserving onboard power since the spacecraft has not been pointing its solar arrays at the sun ever since being launched. Also, uncertainty arose on the status of the propellant supply of the spacecraft and whether sufficient propellant was available to salvage the mission.

All six attempts to make contact were not successful on Wednesday and Progress M-27M remains flying passively in orbit after tumbling out of control in the initial hours of its flight that was originally planned to take the craft to the International Space Station within six hours to mark the delivery of 2,357 Kilograms of food, fuel and supplies to the orbiting outpost, flying 400 Kilometers above the planet and currently hosting six crew members.

Progress M-27M made its way into orbit atop a Soyuz 2-1A rocket that blasted off from the Baikonur Cosmodrome on Tuesday at 7:09:50 UTC to embark on a nine-minute ride into orbit. It was the second time the Soyuz 2-1A version was used to launch a Progress spacecraft in the transition of the older Soyuz U to the modern version of the Soyuz that is expected to take over Progress and crewed Soyuz missions to ISS over the next two years. The first Progress launch atop Soyuz 2-1A last October was uneventful and set the craft up for a nominal four-orbit rendezvous with the International Space Station.

The four-orbit rendezvous was again to be achieved on Tuesday and initially, everything appeared to be going by the book – Soyuz thundered off powered by its boosters and core stage and normal call-outs were made confirming a good trajectory and stabilization of the launch vehicle. After the boosters were separated one minute and 58 seconds into the flight, the core stage continued operation on its own until hot-staging was completed at T+4 minutes and 46 seconds. No issues were reported and the Block I third stage made its burn of 3 minutes and 58 seconds – stabilization was reported as nominal throughout the burn and the shutdown of the engine was announced on time.

Progress was released into orbit eight minutes and 46 seconds after what appeared to be a flawless launch by the Soyuz 2-1A, but problems quickly emerged with the telemetry link to the spacecraft that could not be established at the expected time. With only sporadic bits of data coming from the vehicle, Mission Controllers were unable to confirm whether all KURS navigation and communication antennas were deployed and whether the propulsion system was pressurized as part of the initial setup for orbital maneuvers to be started on the first orbit. It was however confirmed that the Progress had successfully deployed its two power-generating solar arrays.

With a bad telemetry link and only 14 seconds of video received via VHF showing the KURS data display, Mission Controllers could not confirm the exact status of the spacecraft. This prompted the change from the four-orbit rendezvous to the backup plan of a 34-orbit flight profile for a docking at 9:03 UTC on Thursday. Plans of that Thursday rendezvous were abandoned later when it became clear that the Progress was in serious trouble, closing in on a Loss-of-Vehicle scenario.

(/uploads/6/4/0/6/6406961/7446321_orig.jpg)
Photo: Tsenki/Roscosmos

What followed after Progress headed out of communications range was abundant confusion on the state of the spacecraft, its orbit and the performance of the Soyuz rocket. Reports issued by Russian news outlets were conflicting and orbital data provided by U.S. and Russian sources was not matching up – initial USSTRATCOM data showed the Progress & its third stage in an orbit of 127 by 251 and 123 by 306 Kilometers – a very short lived orbit that would have only lasted until the first half of the day on Wednesday before natural decay. Russian radio tracking data indicated that the perigee of the orbit had been close to the expected value of 193 Kilometers, but the apogee, targeted at 238 Kilometers, was showing a +30-Kilometer overshoot indicating an overperformance by the Soyuz rocket.

It took USSTRATCOM several hours to get a precise fix on the orbit of the Soyuz and Progress, issuing another erroneous Elset along the way before the first accurate orbital parameters were released after 21 UTC on Tuesday:

2015-024A (Progress M-27M): 188 x 260 km – Inclination: 51.65 deg. (Epoch 20:50 UTC)
2015-024B (Block I): 176 x 187 km – Inclination: 51.65 deg. (Epoch 20:12 UTC)

The orbit of the Progress will last for at least one week, barring no unexpected change in atmospheric conditions or a spacecraft-induced loss of altitude. Block I is headed for re-entry some time on Wednesday.

(/uploads/6/4/0/6/6406961/1805583_orig.jpg)
Photo: Oleg Artemyev (File)

This orbital data once and for all confirmed that Progress was not in danger of re-entering on Wednesday, April 29. It also confirmed that there was some truth in the speculation of an overperformance of the third stage evident in the higher apogee that is well above the target of 238 +/-5-Kilometers given for this launch of the Soyuz 2-1A.

It is plausible that issues emerged late in the third stage burn of the Soyuz leading up to a botched separation of the Progress spacecraft, sending the spacecraft into a tumble or causing a re-contact between the Progress and the Block I stage, presumably due to residual thrust after an improper engine shutdown and so damaging equipment on the spacecraft leading up to the loss of communications and possibly upsetting the attitude control system of the craft - explaining a later onset of the spinning motion.

Orbital data also confirms that the Progress did not receive parameters for its first two orbit-raising maneuvers that were to be uplinked immediately after spacecraft separation.

Russian media continued to report different versions of potential failure scenarios from issues with the third stage engine to a bad separation between the booster and the spacecraft, however, no confirmation on any causes was provided by the Russian Space Agency as teams continue to work through the data to identify any anomalies - either related to an intrinsic problem aboard Progress or issues induced by the operation of the launch vehicle.

It took Progress a little under 80 minutes to complete almost an entire orbit and arrive back within range of Russian ground stations, but the news was not good. Telemetry from the spacecraft was not usable and the status of the Progress could not be confirmed, but a short blip of video was acquired of the KURS Navigation System Display which showed the KURS System in its nominal B1 Free Flight Mode, but also indicating two warnings: Loss of Attitude Control and an urgent failure message displayed to operators.

(/uploads/6/4/0/6/6406961/5211750_orig.jpg)
Image: NASA TV

KURS Failure Messages

With no luck of regaining commanding of the Progress, Russian Flight Controllers watched as the craft again passed out of ground station range for another lap around Earth.

Commanding was attempted again on the 10:10 UTC comm pass of the Progress, but the spacecraft did not show any signs of response to commands sent from the ground. Video from the external camera was downlinked to the ground for several minutes during the 11:44 UTC communications session, showing the Progress to be in a rapid tumble around the long axis of the spacecraft with body rates in excess of 60 degrees per second, confirming that control of the craft had been lost.

The video again showed the KURS data overlay, indicating that the system had been placed in a Test Mode – whether by automatic command or on ground command is unknown. The Loss of Attitude Control message was still present and a new alert informed Mission Control of the failure of multiple angular rate sensors within the Attitude Determination and Navigation System of the Progress spacecraft.

Commands were uplinked at the end of the communications pass and teams hoped to see improvement when Progress re-appeared after the next orbit, but no usable data was acquired during the final comm pass on Tuesday.

The rapid spin of the spacecraft in an apparent loss of any control by its onboard systems further dimmed the chances of salvaging the mission. Additional concerns emerged given the inability of the Progress to properly charge its batteries by pointing the solar arrays at the sun during day passes. A discussion of fuel consumption based on the KURS Display was also started, however, it is understood that the display does not show the total available quantity of propellant and only indicates propellant available for a certain spacecraft mode. Because the vehicle went into Test Mode, a change of the propellant value in the display could be expected and does not necessarily indicate an excessive use of fuel.

Having exhausted all capabilities on Tuesday to attempt to make contact with the Progress, Mission Control had to stand down for 11 hours since Progress did not have any more communications opportunities until the early hours on Wednesday. The teams at the ground stations were released, but work at Mission Control continued to evaluate the data that had been collected on Tuesday to attempt and develop a plan for the recovery of the mission.

Teams identified an opportunity to attempt to override the spacecraft's onboard control system and switch it to TORU Mode – the Telerobotically Operated Mode that would be used during rendezvous in case of problems inside 400 meters to the Space Station to enable the crew aboard ISS to use hand controllers to manually fly the Progress towards a docking. The new plan was to have Progress switch to TORU mode during the first comm pass on Wednesday with specialists at the controls to use rotational and translational hand controllers to fire the DPO thrusters of the Progress to dampen body rates and restore a stable attitude.

Progress flew within range of ground stations at 1:50 UTC on Wednesday and teams attempted to receive data from the craft to command the switchover to TORU. Media reports and information from TsUP suggests that this first attempt failed to receive any data from the Progress. Attempts will be repeated on five subsequent communication passes on Wednesday, but there is no guarantee on whether the Progress is still capable of sending data given concerns associated with the power generation of the spacecraft.

(/uploads/6/4/0/6/6406961/8813390_orig.jpg)
Photo: NASA

TORU Control Station aboard Zvezda Module

Information was brought forward by the Joint Space Operations Center that tracks objects in orbit and has detected at least 44 pieces of debris close to the Progress M-27M spacecraft. Furthermore, tracking revealed that the spacecraft was spinning at a rate of one revolution every five seconds.

The presence of debris either from the Progress spacecraft itself or the Block I stage of Soyuz confirms an energetic event to have taken place early in the mission. The nature of the event can not be known for certain without insight into telemetry. Debris could have originated in a collision of the third stage of the Soyuz and the Progress spacecraft or in a rupture of a pressurized vessel of the Progress (propellant tank or line, pressurant tank or line, gas tank, or the pressure vessel itself). An energetic event around separation can also explain the higher-than-planned apogee of the orbit. Orbital data of the debris has not yet been released.

Should Progress not make it to the Space Station, there is no immediate danger to the six crew members currently living and working aboard the

orbiting laboratory. ISS has sufficient supplies for at least four months of nominal operations and Progress M-26M (/progress-m-26m-mission-updates.html) remains docked to the Zvezda module of ISS to provide propulsive support to the Space Station. Currently – with Progress in an uncertain status – the only operational ISS cargo spacecraft are the SpaceX Dragon having just made its sixth operational cargo delivery (/dragon-spx-6-mission-updates.html)to ISS, and the Japanese HTV (/htv-spacecraft-information.html) spacecraft that will return to ISS later this year after a longer hiatus.

Cygnus, (/cygnus-spacecraft-information.html) the other U.S, cargo craft, is looking forward to a flight on Atlas V this year before resuming flights to ISS in 2016 using the upgraded Antares launcher that is being developed in response to last October's Antares (/cygnus-orb-3-mission-updates.html) launch failure. ATV, (/atv-spacecraft-information.html) the only non-Russian spacecraft capable of delivering refueling propellant to ISS, retired earlier this year after its fifth visit to ISS.

(/uploads/6/4/0/6/6406961/4986996_orig.jpg)
Photo: NASA

The only immediate concern to ISS operations would be a long stand-down of either the Soyuz/Progress spacecraft – given the high degree of commonality in their various systems - or a grounding of the Block I third stage of the Soyuz. Block I is common across the Soyuz U, FG and 2-1A rockets that are currently in charge of all Russian missions to ISS. At least some definitive information on the failure scenario that transpired on Tuesday has to be gathered before an assessment of any potential effects on subsequent operations can be made such as the undocking of Soyuz TMA-15M in mid-May and the launch of TMA-17M towards the end of May.

Progress is the only spacecraft capable of providing ISS with refueling propellant to be used for the maintenance of the Stations orbit, Debris Avoidance Maneuvers and for attitude control. The M-27M spacecraft is loaded with 2,357 Kilograms of supplies for delivery to the orbital outpost. A detailed breakdown of cargo aboard the craft can be found here. (/progress-m-27m-cargo-manifest.html)

Loss of Control - Progress Cargo Mission to Space Station in Danger

April 28, 2015

The unpiloted Progress M-27M cargo resupply spacecraft packed with supplies for the International Space Station has encountered a serious issue in orbit that may prevent the craft from fulfilling its cargo delivery mission. Communications with the spacecraft deteriorated shortly after its launch from the Baikonur Cosmodrome on Tuesday and the Progress suffered an apparent loss of control, beginning a wild tumbling motion.

(/uploads/6/4/0/6/6406961/3996279_orig.jpg)
Photo: NASA/ESA (File)

Russian Mission Controllers are making attempts to restore commanding and re-gain control of the spacecraft, but only have limited time given the short-lived orbit of the spacecraft. A possible docking attempt that had been rescheduled for Thursday has been called off given the magnitude of problems present on the spacecraft.

The Progress M-27M spacecraft blasted off atop a Soyuz 2-1A rocket at 7:09:50 UTC on Tuesday, embarking on a nine-minute ride into orbit, racing into sunny skies over the Baikonur Cosmodrome.

It was the second Progress to use the upgraded Soyuz 2-1A launch vehicle that is taking over Progress missions from the older Soyuz U that has flown since 1973 and is looking forward to its retirement next year. The previous Soyuz 2-1A – Progress launch was a complete success and showed off the capabilities of the launcher last October, inserting the Progress M-25M (/progress-m-25m-mission-updates.html) spacecraft into an orbit that was remarkably close to the target.

Thundering off under the power of the four boosters and core stage, Soyuz quickly headed uphill, passing the speed of sound just over a minute after liftoff. Calls made from the launch bunker at the Cosmodrome indicated a normal performance of the first stage with good stabilization reported by the launch team. The boosters finished their job one minute and 58 seconds after launch, being jettisoned as the core stage continued powered flight on its own – handing off to the third stage of the Soyuz four minutes and 46 seconds into the flight in the characteristic hot-staging sequence. The third stage then burned for nearly four minutes to loft the Progress into orbit – only normal calls were made during the operation of the upper stage.

Progress M-27M was released from the third stage eight minutes and 48 seconds after what appeared to be a flawless launch – all ascent events occurred at the appropriate times and telemetry-based call-outs indicated a good performance by the Soyuz. Entering orbit, the Progress was planned to go through a series of time-tagged command sequences to deploy its solar arrays and navigation antennas, initiate communications with the ground and prepare its propulsion system for use.

It quickly became clear that the telemetry feed from the spacecraft was only sporadic – only partial data arrived on the ground. Just enough data was collected to confirm that the two power-generating solar arrays had been deployed, but there was uncertainty on the KURS antennas and the propulsion system. A short blip of video was downlinked through VHF showing the KURS data screen that was to be used for a functional test of the system before


(/uploads/6/4/0/6/6406961/8862648_orig.jpg)
Photo: NASA/ESA (File)

Progress headed out of communications range. Towards the end of the ground station pass, communications from the Progress ceased completely.

Mission Controllers quickly made the decision to down-mode the mission from the planned four-orbit to the 34-Orbit Rendezvous Profile, the old two-day approach used before 2012 as the standard mission profile. However, to be able to bring the Progress in for a docking, Mission Controllers had to restore communications with the spacecraft and confirm the deployment of the KURS antennas and the operation of the engines - it was suspected that three antennas did not deploy and the propulsion system remained safed.

During the first orbit of the spacecraft, orbital data came in from Russian news outlets, claiming a 30-Kilometer overshoot on the apogee altitude – blaming the Soyuz rocket's third stage for the troubles encountered by the Progress. And indeed, U.S. Tracking Data seemed to support the claim of an off-target insertion showing the Soyuz third stage and Progress spacecraft in orbits of 126 by 251 and 123 by 306 Kilometers indicating a major error in the insertion orbit since Progress M-27M was aiming for a 193 by 238-Kilometer orbit.

Although this data was cause for concern due to the longevity of such a low orbit, additional tracking data was needed since the initial measurements made by NORAD can be associated with quite large errors.

Without conclusive orbital data, it was only certain that controllers had between a few hours and a few days to recover commanding of the Progress to place it into a higher orbit to avoid an early end of the mission in an uncontrolled re-entry. After its first lap around Earth, Progress M-27M passed over Russian Ground Stations again, allowing Mission Control to attempt to make contact with the spacecraft. Video from the KURS Display was once again seen, but telemetry indicating a KURS or propulsion status could not be gathered.

Commands were sent to the spacecraft, but no signs of command execution were seen leading teams to believe that a malfunction of the onboard computer may be the culprit.

Adding to the overall confusion, Mission Control Moscow claimed that Progress was in an orbit of 193.8 by 278.6 Kilometers based on radio tracking in contrast to the orbital data sets provided by USSTRATCOM. A second Elset provided by U.S. Space Surveillance showed object 2015-024B in a 120 by 316km orbit, backing up the initial measurements, indicating that Progress was indeed in a very short-lived orbit.

A third ground station pass, starting at 10:10 UTC on Tuesday did not bring any improvements with no usable telemetry coming down from the Progress. Again the spacecraft did not respond to any commands that were sent from the ground, indicating that the problem was indeed of a more serious nature with the potential of endangering the whole mission.

Flying passively in an orbit much lower than that of ISS, the Progress quickly caught up over 3,000 Kilometers, passing below ISS and heading out in front with the two orbits beginning to drift out of phase. A propulsive maneuver was needed on Tuesday to protect the 34-Orbit rendezvous, but a fourth comm pass starting at 11:44 UTC again only yielded bits of data from the telemetry and KURS channels.

(/uploads/6/4/0/6/6406961/1630938_orig.jpg)
Image: NASA TV

KURS Data Display

However, the fourth ground station pass delivered some video to the ground showing the Progress M-27M spacecraft in an uncontrolled tumbling motion at a significant rate of around 60 degrees per second along the long spacecraft axis which confirms that the vehicle has lost attitude control and can not use its propulsion system, further dimming the prospects of recovering the mission and regaining control over the spacecraft. The cause of the tumbling motion is unknown and could range from a botched separation from the launcher, to a leak in a propellant/gas line or tank or even point to a stuck thruster.

Data collected by Mission Control showed the failure of multiple rate sensors within the navigation system of the Progress. It has to be noted that the video and telemetry systems of Progress use different downlink paths, explaining the difference in video and data quality.

Commands were sent to the Progress to initiate a stabilization of the vehicle with the outcome of those commands awaited during the final comm pass of the day. Nothing was heard from M-27M on that 13:17 UTC pass - MCC is out of touch with the spacecraft until Wednesday.

Mission Controllers in Moscow will continue working on plans to restore commanding of the Progress spacecraft, developing troubleshooting plans for Wednesday's communications sessions, but orbital dynamics will no longer allow a rendezvous with ISS for a docking on Thursday, even if all problems could be resolved.

Nevertheless, there is some sense of urgency since the low orbit of the Progress is decaying naturally within a period of two or three days.

(/uploads/6/4/0/6/6406961/8740584_orig.png)
Image: NASA TV

Roscosmos demonstrated that the agency is capable of pulling missions from dire straits only recently when the Foton M-4 satellite (/foton-m-4-mission-updates.html) stopped communications with the ground for nearly a week before teams could implement a fix and save the mission, fulfilling all objectives.

Any implications of the impending Progress failure can not be foreseen yet since it is unknown what caused the trouble with the vehicle in the first place – it is uncertain whether the spacecraft or the launch vehicle is to blame. Both share commonality with the systems that will be in use next month for the launch of Soyuz TMA-17M that will carry three crew members to ISS. Soyuz shares some commonality with the systems of the Progress, but a bigger problem may arise if the third stage of the Soyuz rocket can not be exonerated because the Block I is identical between the Soyuz U, FG and 2-1A vehicles that are currently carrying all Russian flights to ISS.

Progress Cargo Craft faces Problems after Launch into Orbit, Docking delayed

>>>Launch Photos (/progress-m-27m---soyuz-launch-photos.html)

April 28, 2015

(/uploads/6/4/0/6/6406961/7025279_orig.jpg)
Photo: Tsenki/Roscosmos

The next resupply craft headed to the International Space Station was launched on Tuesday by a Soyuz 2-1A rocket that blasted off from Site 31/6 at the Baikonur Cosmodrome at 7:09:50 UTC to deliver the Progress M-27M cargo vehicle into orbit for a planned fast-track rendezvous with the orbiting complex.

Despite what seemed to be a successful mission performed by the Soyuz 2-1A, marking the second time the modernized Soyuz lofted a Progress, the spacecraft ran into trouble immediately after separation from the rocket. Data received at mission control was sporadic at best and contact with Progress was lost for longer periods during the initial phase of the mission. It could not be confirmed whether all of the navigation antennas of the spacecraft had deployed and Mission Controllers in Moscow decided to down-mode the mission from a four-orbit rendezvous to a 34-orbit profile to give teams additional time to look into the apparent communications problems with the Progress.

The 46-meter tall Soyuz rocket blasted off on time from its Kazakh launch site, climbing into sunny skies under the loud thunder of its engines that

delivered a liftoff thrust of 422 metric ton-force to lift the Progress into orbit. The four boosters of the Soyuz rocket burned for one minute and 58 seconds before separating from the launcher, being sent into a tumble back to Earth for an impact downrange from the launch site. Soyuz headed onwards powered by its core stage alone that burned until T+4 minutes and 45 seconds when the vehicle completed its hot-staging sequence, firing up the engine of the third stage and cutting the connection to the core stage.

Burning for three minutes and 58 seconds, the third stage of Soyuz carried the 7,289-Kilogram Progress spacecraft into orbit. Progress M-27M was targeting an insertion orbit of 193 by 238 Kilometers at an inclination of 51.67 degrees at a phase angle to the ISS orbit around 28 degrees.

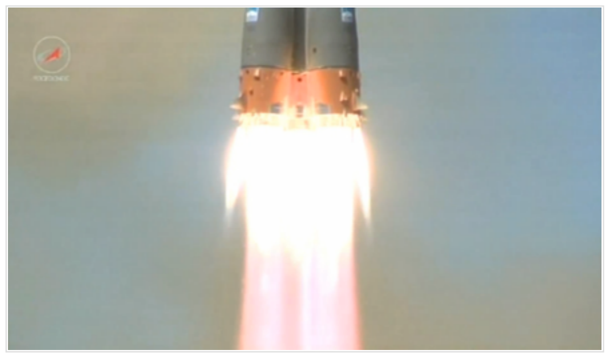
A precise insertion was required for the Progress to be able to make its fast-track rendezvous, but with the new guidance system aboard the modern Soyuz 2-1A instead of the older analog system used by the Soyuz U, precision of the orbital insertion was not a concern that teams had on their minds.

The third stage shut down its engine at T+8 minutes and 45 seconds with spacecraft separation three seconds later. Immediately after separation, the Progress was to deploy its two power-generating solar arrays and KURS navigation antennas in a sequence that uses time-tagged commands. Also, the spacecraft was to begin communications with ground stations and prime is propulsion system. Normally, these events are confirmed within a period of seconds through real-time telemetry.

However, telemetry data from the Progress was coming in sporadically at best and teams had trouble confirming the deployment events. Sufficient data arrived to confirm that the two-power generating solar arrays had been deployed successfully, but the deployment of the KURS antennas could not immediately be confirmed. A short blip of video was received through the VHF tracking stations showing the normal KURS data screen that was to be used for a test of the system after orbital insertion. It appeared that data from the Progress was then lost altogether and could not be reacquired until the craft headed out over the Pacific Ocean.

Mission Controllers were busy working through the data they received to diagnose the extent of the communications problem and attempt to trace down a possible cause for corrective actions to be developed. It could not be fully confirmed which antennas were deployed and controllers were awaiting additional data from the second ground station pass of the Progress one orbit after launch which will also show whether the craft executed a pair of engine burns that were programmed to take place during its first lap around Earth.

(/uploads/6/4/0/6/6406961/1025335_orig.jpg)
Photo: Tsenki/Roscosmos



(/uploads/6/4/0/6/6406961/7188671_orig.png)
Photo: Tsenki/Roscosmos

Given the compressed timeline of the four-orbit rendezvous, there is no margin for any errors in the initial phase of the mission, requiring the switch from the fast rendezvous to the 34-Orbit Mission Profile that once was the standard flight plan for Progress and Soyuz missions to Mir and ISS before the quick flight scheme was inaugurated in 2012.

Provided the problems with the spacecraft can be solved and commanding restored, Progress would be inbound on Thursday, around 9 UTC for a docking to the Pirs module of ISS.

Reports coming from Russian news outlets indicate that the Soyuz rocket was to blame for the communication problems due to an off-target insertion into a higher orbit, however, this information was not confirmed by Roscosmos. Orbital tracking data of the Progress seems to confirm that the launch vehicle delivered the craft to an erroneous orbit.

Two objects related to this launch were tracked (Soyuz third stage & Progress M-27M) and the following orbital data was released by Joint Space Operations Center:
2015-024A - 127 x 251 km, Inclination: 51.57°
2015-024B - 123 x 306 km, Inclination: 51.57°

Next ISS Progress Cargo Craft ready for Liftoff atop Soyuz 2-1A

April 27, 2015

A Russian Soyuz 2-1A rocket is ready for liftoff from Site 31/6 at the Baikonur Cosmodrome on Tuesday at 7:09 UTC to send the Progress M-27M cargo resupply craft into orbit for an express rendezvous with the International Space Station to keep up a steady chain of supplies to the Space Station and its crew of six.


(/uploads/6/4/0/6/6406961/7205875_orig.jpg)
Photo: Roscosmos

Following the rollout of the Soyuz booster on Sunday, teams began the final preparations for the start of countdown operations on Tuesday to get Soyuz 2-1A ready for liftoff. This is the second launch of a Progress atop the Soyuz 2-1A launcher that is taking over from the Soyuz U that will make its final flight next year. Soyuz U made more than 700 launches since 1973 with a success rate of over 97%, supporting crewed flight operations to the Salyut, Mir and ISS space stations plus lifting a variety of satellites over its career.

Soyuz 2-1A features an improved digital guidance system and modified engine injector technology to increase payload capability and provide a significant increase in insertion accuracy.

The launch countdown will be initiated eight hours ahead of the planned daytime launch target on Tuesday. Once the Soyuz and Progress are activated, they undergo a series of checkouts of their flight control systems. Communication checks, electrical testing and propulsion system testing is also performed in the early stage of the countdown. Completing final hands-on work on the launch vehicle, engineers will install batteries in the booster and remove protective covers from the Soyuz including the first stage engine covers.

At L-5 hours, the Russian State Commission convenes for the final pre-launch reviews of the countdown status to give the formal approval for Soyuz propellant loading. At that point, teams will be busy working on the Soyuz as final hands-on tasks and fueling preparations are being made. After the tanking cars pull up to the pad, they are connected to propellant systems to initiate the propellant loading procedure approximately four hours before liftoff. The 12 tanks of the Soyuz will be filled with a total of 272,140 Kilograms of rocket-grade Kerosene and –183°C Liquid Oxygen.

In addition, the boosters and core stage are loaded with liquid Nitrogen for tank pressurization and Hydrogen Peroxide to drive the turbopumps of the engines. Fueling wraps up about two hours before launch, allowing teams to perform final close-outs of the launch vehicle and pad structures.

>>>Soyuz 2-1A Launch Vehicle Overview (http://www.spaceflight101.com/soyuz-2-1a.html)
>>>Soyuz Countdown Timeline (http://www.spaceflight101.com/soyuz-generic-cdt.html)

During the final hour of the countdown, the Soyuz will go through a final set of tests and the Service Structure is retracted to clear the way for liftoff.

The Guidance System of the rocket will be configured for launch and teams will evacuate the launch pad ahead of the Terminal Countdown Sequence. Heading into the automated countdown sequence six minutes before liftoff, the Soyuz completes final reconfigurations including propellant tank pressurization, engine purge, and the transfer to onboard power and control. Twenty seconds before launch, the RD-107A and RD-108A engines on the boosters and Core Stage come to life and soar up to intermediate thrust levels before throttling up to a total liftoff thrust of 422,000 Kilograms.

Blastoff is expected to occur at precisely 7:09:50 UTC as Soyuz rises from its pad under the power of its boosters and core stage, completing a short vertical climb before pitching and rolling onto its precise ascent trajectory to begin heading to orbit. Roll capability is new for a Progress launch, provided by the digital guidance system of the Soyuz.

The four liquid-fueled boosters will burn for 1 minute and 57.49 seconds, consuming 39,200 Kilograms of liquid oxygen and Rocket Propellant-1. Separation of the

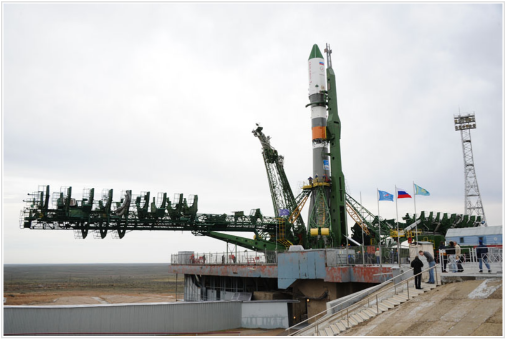

(/uploads/6/4/0/6/6406961/784149_orig.jpg)
Photo: Roscosmos


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Photo: RSC Energia

boosters is accomplished using pyrotechnics and pistons that send the four 19.6-meter long boosters into a tumble back to Earth for a crash landing 355 Kilometers downrange from Baikonur (7km further downrange than for Soyuz U).

With the boosters gone, the core stage will continue firing its RD-108A engine, delivering 101 metric tons of thrust to continue powering the vehicle. The Core Stage will burn until T+4:46.89 when its engine will be shut down. Moments later, the third stage of the Soyuz ignites its engine and the pyrotechnic stage separation system is fired as part of the hot-staging sequence employed by the Soyuz.

This will enable the third stage to pull away from the spent Core Stage and continue the journey into orbit while the 27.8-meter long core falls back to Earth for impact 1,550 Kilometers downrange (20km short of the Soyuz U impact Zone).

Ten seconds after the RD-0110 engine of the third stage ignites, the Soyuz will jettison its payload fairing to expose the Progress for the rest of the way into orbit. The separation of the third stage's aft section occurs 0.23 seconds after fairing separation to enable all items to impact in the same location, 1,576 Kilometers downrange from the launch site.

In previous Progress ascent mission by Soyuz U, the fairing was dropped at T+2 minutes and 40 seconds, but Soyuz 2-1A will hold the fairing for another two minutes and 15 seconds.

The reasoning behind this is to deliberately reduce the overall ascent performance by holding the extra weight of the fairing longer in order to keep the previous drop zones of boosters, core stage and third stage aft-section. Drop-zones for vehicles launching from Baikonur have often been a source of conflict between Russia and Kazakhstan causing several launch delays while negotiations on a political level were underway to clear the way for new drop zones to be approved. Progress MS, to be inaugurated in October 2015, will be capable of holding a larger cargo upmass which will likely result in the shroud jettison taking its old spot in the Soyuz launch timeline.

The 298-Kilonewton RD-0110 engine of the Upper Stage performs a 3-minute 58-second engine burn to finish the job of lifting the Progress into orbit. With the completion of the burn, the stack will be in orbit with spacecraft separation planned at T+8:48.27.

Progress M-27M is targeting an insertion orbit of 193 (+/-2) by 238 (+/-5) Kilometers inclined 51.67 degrees. These orbital parameters reflect the increased insertion accuracy delivered by Soyuz 2-1A as the margins for both, perigee altitude and apogee, have been reduced significantly. Being delivered to an orbit at a 28-degree phase angle to that of ISS, Progress M-27M will complete solar array and KURS antenna deployment ahead of a KURS test before flying out of communications range.

Using the expedited Rendezvous Profile, Progress M-27M will make two pre-programmed burns during its first orbit around Earth. Two additional burns are performed on the second orbit, however, those burns are re-planned after launch based on the actual insertion orbit and uplinked to the Progress during its first ground station pass. These four large engine burns will set the Progress up to begin its Automated Rendezvous Sequence at 11:01 UTC.

Over the course of the automated rendezvous, the Progress performs a series of engine burns guided by its KURS navigation system to link up with ISS for a flyaround followed by Stationkeeping and final approach.

>>>Progress M-27M Mission Profile (http://www.spaceflight101.com/progress-m-27m-flight-profile.html)

Docking to the Pirs Module is planned at 13:06 UTC to mark the start of a busy docked mission.

Progress M-27M has a launch mass of 7,289 Kilograms including 2,357 Kilograms of cargo that is comprised of 494 Kilograms of refueling propellant for transfer to ISS tanks, 420kg of water, 50kg of pressurized oxygen for ISS repressurizations and 1,393 Kilograms of dry cargo being ferried to ISS inside the pressurized cargo carrier of the Progress.

The dry cargo delivered by the Progress includes 215kg of sanitary

equipment (replacement components for the Russian toilet facility, water system hardware and hygiene supplies), 136kg of medical supplies, cleaning equipment & clothing, 391kg of food, 43kg of thermal control system hardware, 57kg of personal protective equipment, 91kg of electrical power system hardware, 13kg of ventilation system components, 23kg of water system hardware, 6kg of data system components, 43kg of crew support equipment, 32kg of science hardware, and 111kg of various outfitting materials for the Russian modules.

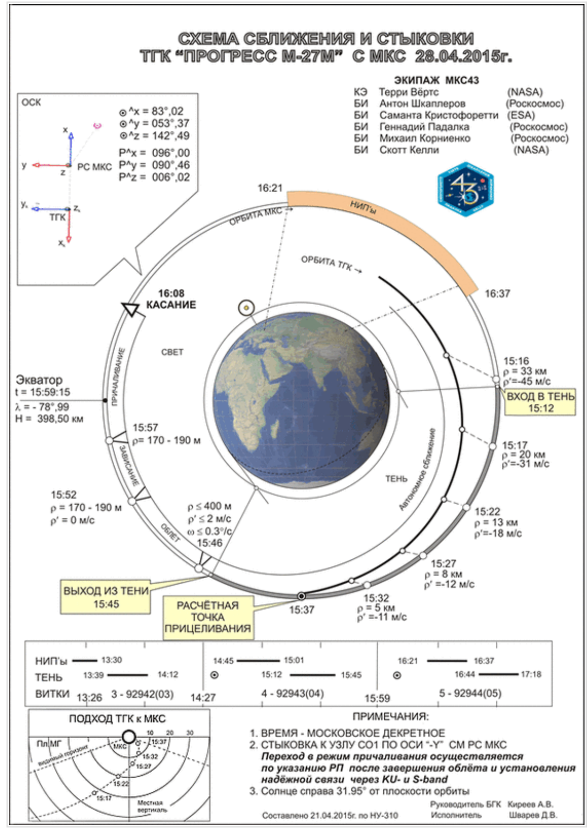

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Image: Roscosmos/TsUP

Also onboard are 116 Kilograms of American cargo for the Russian crew including food and hygiene materials and 115kg American hardware for the USOS crew plus 1kg of ESA hardware.

Soyuz Rocket rolls to Baikonur Launch Pad to Loft Progress Resupply Craft

>>>Spacecraft Processing Photos (/progress-m-27m-spacecraft-processing.html) >>>Launch Vehicle Integration (/progress-m-27m-launch-vehicle-integration.html) >>>Soyuz Rollout (/progress-m-27m-soyuz-rollout.html)

April 26, 2015

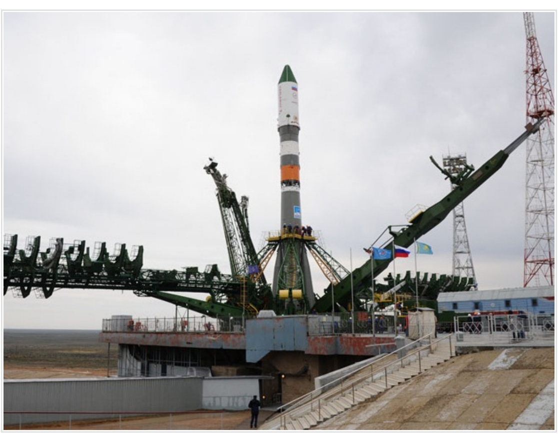
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Photo: RSC Energia

The Soyuz 2-1A Rocket carrying the Progress M-27M Space Station Resupply Spacecraft was rolled to the launch pad - Site 31/6 at the Baikonur Cosmodrome - on Sunday in advance of the craft's liftoff on a journey to the International Space Station. Preparations remain on track for liftoff of the Soyuz on Tuesday at 7:09 UTC to send the Progress on a four-orbit rendezvous with the Space Station for docking six hours after liftoff.

The Progress spacecraft was moved to the Launcher Integration Facility on Thursday after completing its pre-launch processing campaign at Site 254 of the Cosmodrome, undergoing checkouts, cargo loading, fueling and final inspections before being encapsulated in its protective launch shroud.

At the Launcher Integration Facility, work had been underway since April 10 - the components of the Soyuz rocket were readied for assembly. Prior to the Progress arriving at the facility, the Core Stage of Soyuz had its four liquid-fueled boosters installed and initial preparations of the launcher's third stage were made.

Enclosed in its protective fairing, the Progress was installed atop the third stage via the Payload Adapter that provides structural interfaces to the spacecraft, the upper stage and the payload shroud. Although this mission uses the Soyuz 2-1A that can support several fairing designs, the Progress uses the traditional launch shroud that has been in operation for many years.

Electrical and data lines from the spacecraft to the fairing, spacecraft and payload adapter were mated and the engine covers from the third stage were removed before the stage was moved into position to the attached to the large Core Stage to mark the completion of the integration process, wrapping up with the connection of data lines in the interstage and a series of testing operations.

Overall, the Soyuz 21-A has a launch mass of 308,000 Kilograms, standing 46 meters tall with a core diameter of 2.95 meters.

This is the second Progress mission to use the Soyuz 2-1A, the first having been Progress M-25M (/progress-m-25m-mission-updates.html) that made its fiery re-entry on Sunday to finish up its six-month mission. Soyuz 2-1A (/soyuz-2-1a.html) is succeeding the Soyuz U (/soyuz-u.html) version that first flew in 1973 and made over 700 launches, becoming one of the workhorses of the Russian Space Program, also launching crewed Soyuz spacecraft to the Salyut and Mir Space Stations as well as ISS and as part of the Apollo-Soyuz Test Project.

Soyuz 2-1A has been flying for a decade and is now considered a fully mature rocket which is no longer subject to any teething problems, ready to start taking over Progress flights to ISS and, when successful, also take over crewed missions from the Soyuz FG rocket starting in 2016. Initially, Progress launches are alternated between Soyuz U and 2-1A to reduce risk and allow a longer period in between 2-1A flights to sort out potential problems should any arise. Soyuz 2-1A features an improved digital guidance system and improved engine injector technology to increase payload capability and provide a significant increase in insertion accuracy.


(/uploads/6/4/0/6/6406961/7242099_orig.jpg)
Photo: RSC Energia

With Soyuz 2-1A fully assembled, the Russian State Commission met on Saturday to review the status of launch preparations, the results of initial launch vehicle testing and the readiness of the ground systems including those at Site 31/6 which had been prepared to support the launch over a period of weeks.

No open items were discovered and the official approval for the rollout of the launch vehicle was given.

Per the old tradition, the rollout commenced in the early hours on Sunday in a setting that has not changed since Yuri Gagarin’s historic flight in 1961. Riding atop rails, the Soyuz rocket slowly made its way to Site 31/6, attended by many Cosmodrome workers.


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Photo: RSC Energia


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Photo: RSC Energia

Once at the pad, the Soyuz was placed in its vertical launch position using the Transporter-Erector.

With Soyuz standing atop its launch pad, the two halves of the Service Structure were moved into position to provide access platforms to technicians for the normal L-2 processing flow. The umbilical towers that interface with the boosters, the core stage and the third stage were moved into position so that teams can connect the various propellant, pressurant and purge lines as well as electrical and data umbilicals.

A detailed set of tests will be run to evaluate the performance of the launch vehicle and on Monday, technicians will make preparations for propellant loading before teams will head into countdown operations early on Tuesday, about eight hours prior to the planned launch time.

Soyuz 2-1A is set for liftoff at 7:09:50 UTC based on the latest tracking data obtained from ISS since the launch time has to be precisely calculated to enable the Soyuz to deliver the Progress to a precise position in space, flying below ISS and trailing the complex while also flying at a low phase angle to the Station to be able to make its rendezvous within six hours of liftoff. The Soyuz will provide the 7,290-Kilogram cargo ship with a nine-minute ride into a Low Earth Orbit from where the Progress will climb up to link up with ISS. Docking is planned at 13:06 UTC on Tuesday.

Progress M-27M is delivering around 2,350 Kilograms of cargo to the International Space Station, including refueling propellant, water, repressurization gas and dry cargo. A detailed cargo manifest has not yet been released by the Russian Space Agency.

Progress M-27M finishes Processing for Launch to ISS next Week

April 22, 2015

>>>Spacecraft Processing Photos (/progress-m-27m-spacecraft-processing.html)

The next Progress Space Station resupply craft has finished its pre-launch processing campaign at the Baikonur Cosmodrome and is ready to be integrated atop its Soyuz 2-1A launch vehicle. Liftoff of the Progress is set for Tuesday at 7:09 UTC, marking the start of a six-hour trip to ISS for a delivery of 2,350 Kilograms of cargo for the six crew members aboard the orbiting complex.

Before Progress M-27M can launch, its docking port on the Pirs Module of ISS has to be vacated by Progress M-25M (/progress-m-25m-mission-updates.html) that is set for undocking on Saturday at 6:40 UTC for a free flight of one day ahead of the deorbit burn on Sunday.

Progress M-27M is the second Progress to launch on the Soyuz 2-1A variant in the transition of Progress from the older Soyuz U (/soyuz-u.html) that is initially performed by alternating between the two launch vehicle versions to allow sufficient time in between 2-1A launches for fine-tuning in case changes are required.

(/uploads/6/4/0/6/6406961/1838236_orig.jpg)
Photo: RSC Energia

Progress M-26M was launched by the Soyuz U and so will Progress M-28M and M-29M before all Progress missions switch to the Soyuz 2-1A, marking the retirement of Soyuz U after more than 700 launches over four decades.

The successor of the Soyuz U and Soyuz FG variants, known as the Soyuz 2, has been flying for a decade, but from the start, it was planned only to hand over flights in support of ISS operations to the newer Soyuz when it finished testing and was fully established. First, Soyuz U will be phased out as Soyuz 2-1A takes over Progress launches to ISS. Soyuz FG will continue flying until at least 2016 when it will also be replaced by the 2-1A variant.

The main difference between the Soyuz U and the Soyuz 2-1A is the flight control system as Soyuz U uses the old, analog control system while the 2-1A uses a modern, digital system that increases the overall capabilities of the rocket giving it the ability to roll onto a given launch azimuth after liftoff and significantly improving the insertion accuracy into a given orbit.

For Progress missions launched by Soyuz U, there was a large error bar associated with the orbital insertion: +7/-15 Kilometers on perigee and +/-42km on apogee. These values now show +/-2 and +/-5km for Progress launched by Soyuz 2-1A. Another change from Soyuz U to Soyuz 2-1A is a slight modification to the core stage and booster engines' injection systems which, coupled with the better control system, adds about 400kg to the vehicle's LEO payload capability.

(/uploads/6/4/0/6/6406961/5570065_orig.jpg)
Photo: RSC Energia

Preparations for the launch of Progress M-27M started back in October 2014 when the spacecraft was delivered to the Baikonur Cosmodrome for its pre-launch processing campaign. Placed in a test stand, the Progress underwent a series of autonomous electrical tests involving all the subsystems to verify that the Flight Control System of the craft was operating normally and all electrical systems were up and running.

The spacecraft was put through vacuum checks to confirm the tightness of the Cargo Module followed by communications checks with the spacecraft. Cargo loading was completed over the course of the vehicle's stay at the Spacecraft Processing Facility.

In early April, the Soyuz 2-1A launcher started assembly at the Launcher Integration Facility. The four 19-6-meter long boosters were attached to the Core Stage of the Soyuz, measuring 27.8 meters in length. The third stage of the vehicle was readied for integration with the Progress and teams ran tests on the assembled core and boosters.

The Progress M-27M spacecraft was moved to the Hazardous Processing Facility on April 14 to be loaded with Nitrogen Tetroxide oxidizer and Unsymmetrical Dimethylhydrazine fuel for use by the KTDU Main Propulsion System and DPO attitude control thrusters. Refueling tanks that hold propellant for transfer to ISS were filled as well. Also, two Helium spheres were charged to provide tank pressurization in flight and Progress M-27M was loaded with Oxygen and Nitrogen gases to repressurize the International Space Station's atmosphere.

When fueling was complete, the Progress was returned to the Spacecraft Processing Facility for final cargo loading and inspections. On Monday, the Progress was installed atop its Payload Adapter that joins the spacecraft to the launch vehicle and provides interfaces with the payload shroud of the launcher. The last red-tagged 'remove before flight' items were removed from the docking system, solar arrays and communication antennas of the Progress spacecraft before the vehicle was rolled to a horizontal position on Tuesday.

After final inspections and clean-up of the payload fairing, Progress was encapsulated in the fairing and structural attachments were made. The fairing for this mission features commemorative decals for the celebration of Victory Day on May 9, the 70th anniversary of Russia's victory in the Second World War.

The Progress is now ready for the transfer to the Launcher Integration Facility to be installed on the third stage of the Soyuz launch vehicle that will then be mated to the Core Stage of the rocket to mark the conclusion

of the build-up of the launcher ahead of rollout to the pad.

Soyuz 2-1A is set for liftoff from Site 31/6 at 7:09 UTC on April 28, 2015 for a nine-minute ascent mission to deliver the Progress to an initial orbit from where the spacecraft will make its climb towards the Space Station orbiting at an altitude of 400 Kilometers. Docking to the Pirs module is planned at 13:07 UTC after a four-orbit rendezvous.

(/uploads/6/4/0/6/6406961/4191620_orig.jpg)
Photo: Roscosmos

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